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Soil Erosion 1955 to 1974
A Review of the Incidence of Soil Erosion in the Dundas Tableland Area of Western Victoria, Australia

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Abstract: This paper presents a review of soil erosion incidence in the Dundas Tableland area of western Victoria after a lapse of almost 20 years. In 1955 the author concluded that the area was naturally unstable. At that time mass slope movements were widespread and both sheet and gully erosion were serious. In 1974 mass slope movements had been reduced by 66%. Slope stability had been almost re-established although erosion remained active along the drainage lines as a result of the time lag in catchment readjustment. The improvement is attributed to alteration in the hydrological balance brought about by pasture improvement, rabbit eradication, conservation control measures, and latterly by changing land use as beef cattle replace both sheep and dairy cattle.

INTRODUCTION

Empirical soil erosion studies necessarily record a given situation at one moment in time. Repetitive and comparative studies of the same area over time are, however, rare, despite acknowledgement of the dynamic processes involved. This paper records, after a lapse of 19 years, some changes in soil erosion intensity in the Dundas Tableland area of western Victoria and attempts to account for the differences seen, in terms of alteration to the hydrological balance.

The Dundas Tableland area was originally selected for study as soil erosion there was both severe and localized (Fig. 1). Isolation of contributory factors was therefore possible. Fieldwork was carried out during the spring and early summer of 1955 following a series of good seasons and firm agricultural prices. The area was revisited during January 1974, again following a good pasture growth season. Since both studies were undertaken in favourable seasons impressions were comparable. However, during the intervening years drought and economic recession had affected the district.

THE AREA

In 1955 landslides scarred many slopes in the Dundas Tableland area. Most catchments were affected by sheet erosion, to a greater or lesser extent, and gullied drainage lines were commonplace. Accelerated erosion was already then 100 years old; landslides and gullies became manifest from 1850, within 13 years of first settlement (Robertson 1853). The 1955 study† of the relationship between soil erosion and landform processes concluded that the area was naturally unstable (Marker 1959). A precarious hydrological balance, established following a dynamic Cainozoic geomorphic history, had been upset by European land utilization.

The Dundas Tableland area is a former promontory between the Murray Basin and Otway Sunkland Tertiary depositional troughs. A resistant Tertiary lateritic palaeosol has been dissected by periodic rejuventation as the Cenozoic seas withdrew. Slopes, separated by level laterite-capped interfluves, are concave upwards and often also oversteepened at the base. The laterite palaeosol has developed on sediments of varying ages and cohesion, with the result that erosion susceptible strata and associated soils are juxtaposed in a dynamic geomorphic situation.

† The 1955 study was presented as M.Ag.Sc. (Melbourne) dissertation; in 1974 the author was visiting lecturer in the Department of Geography, Adelaide University, in receipt of CSIR (South Africa) post-doctoral bursary.

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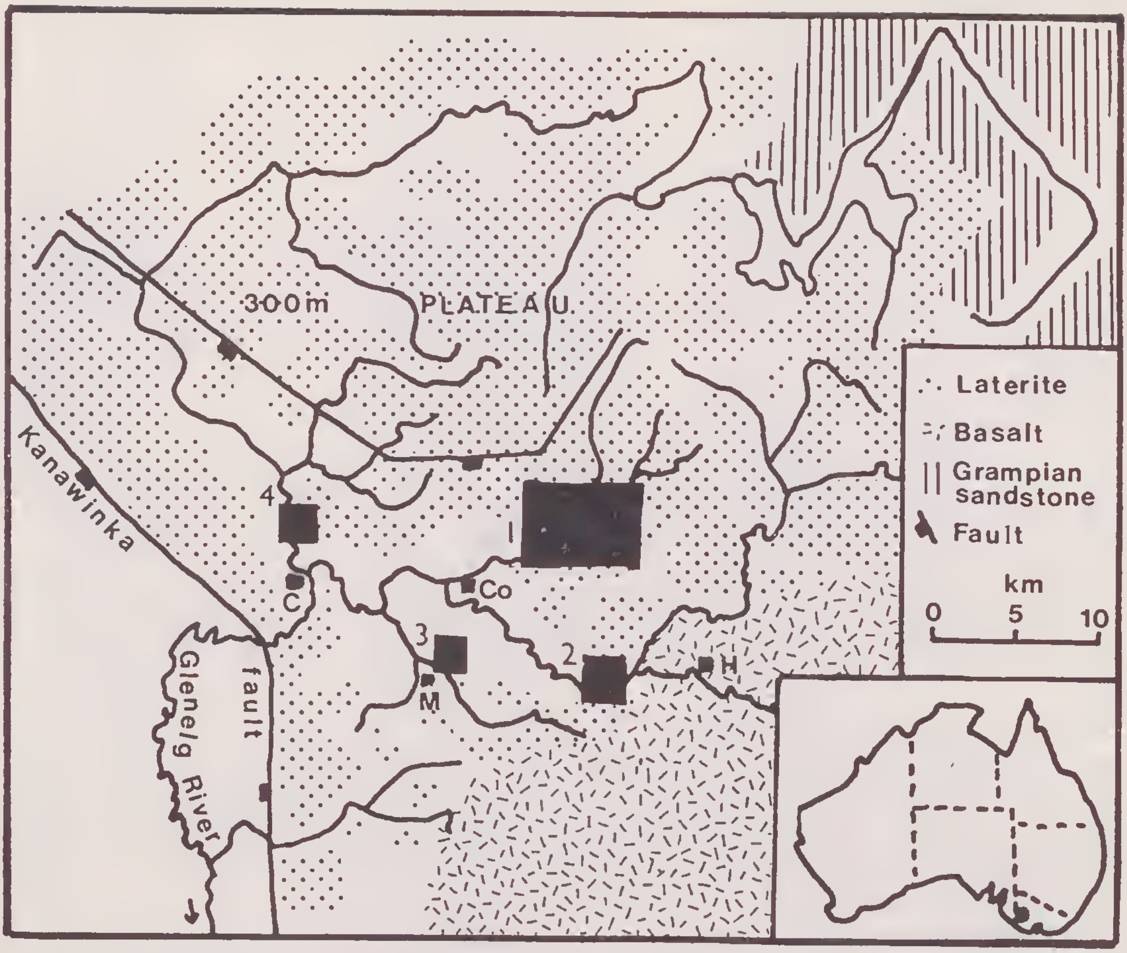

Fig. 1—Location map showing sites of four detailed study areas: 1. Koroit Creek, Coleraine; 2. Murndal; 3. Merino; 4. Noss, Casterton. (C = Casterton, Co = Coleraine, M = Merino, H = Hamilton.)

SOIL EROSION 1955 TO 1974

Soil erosion intensity in 1974 is much diminished and its manifestations are less conspicuous. Sheet erosion now affects only a low percentage of slopes, totally unvegetated landslides are rare and slumping gully walls have become the exception rather than the rule (Pl. 5). The impression gained is one of marked general improvement.

Slope instability was always accentuated by deep incision, by cracking montmorillonite clay soils developed from Permian glacial and fluvoglacial deposits and from Mesozoic lacustrine sediments, and by seepage affecting the B and C clay horizons of the 10 m thick laterite palaeosol capping. The largest and most severe landslides were initiated in these laterite clay horizons on the upper slopes. Smaller mass movements were initiated mid-slope and on the footslope undermined by channel incision.

In any catchment affected by soil erosion of this nature, the future re-establishment of equilibrium conditions will be manifest on the slopes before the channels become stabilized. Four areas severely affected by slope mass movements in 1955 were therefore studied in detail to establish whether the impression of general improvement was valid (Fig. 2). The areas included a total of 100 landslides, of which 35 were already inactive in 1955 and 5 are new features (Table 1). Some movement was perceptible in 28% of all landslides but of these, only 12% were actively mobile. This figure of 28% compares favourably with the figure of 64% for 1955. The general impression that improvement has occurred and that slope stability has been restored appears to

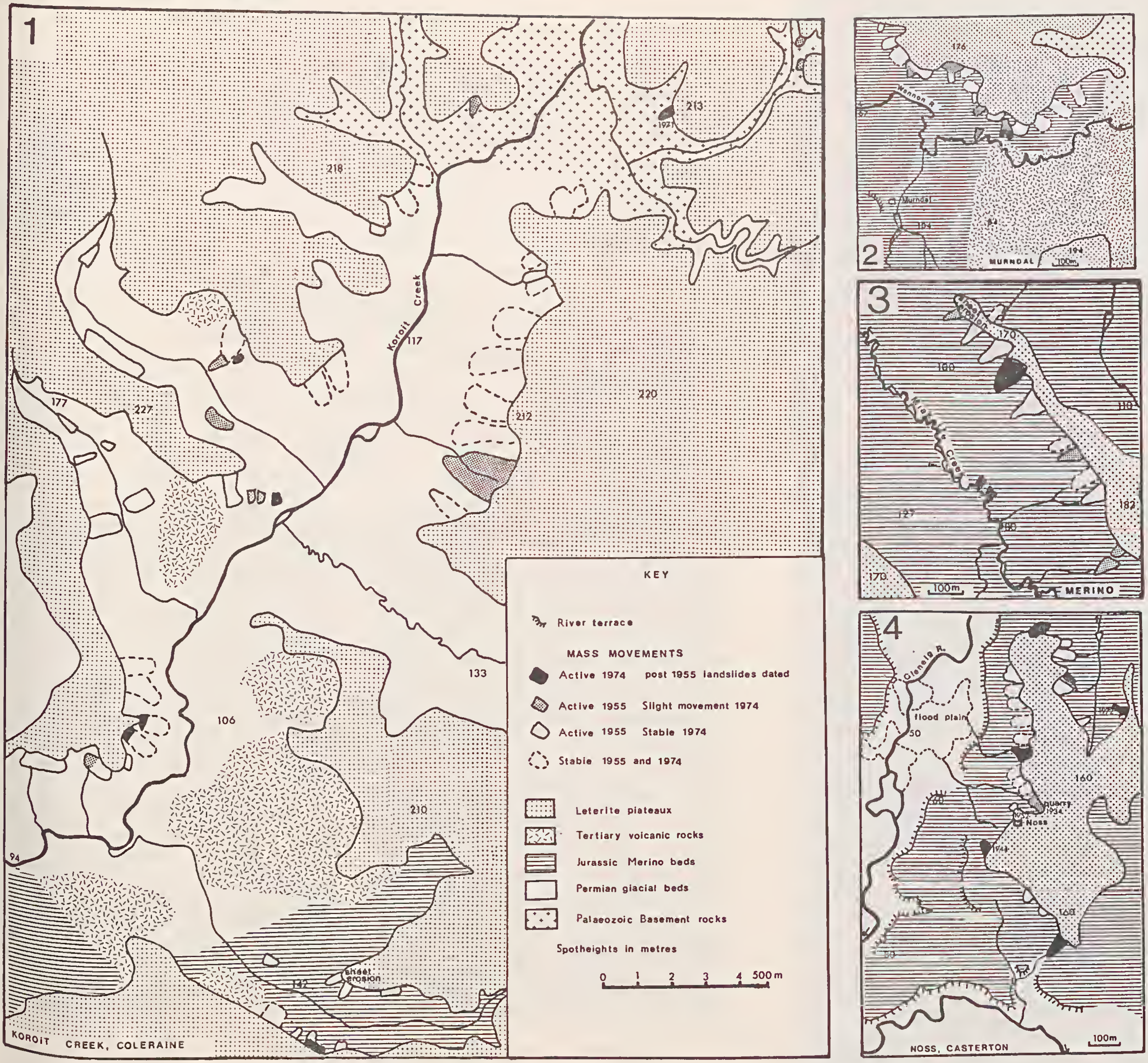

FIG. 2—Detailed study areas: 2·1 Koroit Creek, Coleraine; 2·2 Murndal; 2·3 Merino; 2·4 Noss, Casterton. (Key applies to all figures; alluvium left blank on figure 2·4.)

TABLE 1
LANDSLIDE INCIDENCE (numbers) AT FOUR SELECTED SITES 1955 AND 1974

	Murndal	Noss	Koroit	Merino
Total landslides	20	22	46	12
1974 Active (partially vegetated)	1	6	4	1
1974 Slightly active	4	1	7	4
1974 Sub Total	5	7	11	5
1955 Active (unvegetated)	13	14	25	9
1955 Stale old scars	6	7	19	3
Post 1955	1	1	2	1

TABLE 2
LANDSLIDE VULNERABILITY GRADIENTS

	Mean altitude (m)		Parent material	Overall gradient	Mean angles of landslide (degrees)	
	Laterite plateau	Drainage line			Fracture zone	Solifluction tongue
Murndal	175	70	Mesozoic beds	1:3	33	22
Noss	162	60	,, ,,	1:3	24	16
Koroit Creek	206	142	,, ,,	1:3	23	15
	201	105	Permian beds	1:5	25	14
Merino	180	80	Mesozoic beds	1:6	20	11

be valid. Only 44% of all active 1955 landslides still show signs of movement. Furthermore, since these figures have been derived from analysis of four particularly vulnerable areas, it is likely that over the entire area the percentage improvement is greater.

Mass slope movements occur most readily on long steep slopes immediately beneath the laterite capping (Table 2). The vulnerable slope at Murndal is undercut by the Wannon River (Fig. 2.2), the slope at Noss near Casterton (Fig. 2.4) is a former river cliff now terminating in a terrace footslope. However, mass movement also occurs on shorter slopes where tributary creek junction is vigorous. This appears to be the case in the upper Koroit Creek catchment north-east of Coleraine (Fig. 2.1), and in the Miakite Creek catchment near Merino (Fig. 2.3). Although this may represent basal sapping, it is more likely to indicate the presence of seepage water which lubricates the tongue movement while feeding into the gully. Mass flowage, or solifluction, occurs prior to collapse, along concave slip planes, in the upper, more compact portion of the slope. Solifluction is self maintaining on very low angle slopes when soil coherence is low or lubrication is available. The problem of slope stability is therefore related to the availability of seepage water which is a function of the hydrological balance.

In most cases slopes of less than 20° are stable but where landslides have once occurred, movement can continue on slopes of 10° to 20°, and in one case localized oversteepening has resulted in continuing movement on an overall slope of only 5°. On unstable, triple-lattice, expanding clay soils, solifluction is the normal slope recession process, excess water providing a trigger mechanism. Many landslides were initiated in 1946, an exceptionally wet year with abnormal autumn rains, in 1952, and again in 1971. These were all wet years following a series of adequate rainfall seasons when soils rapidly reached a state of saturation (Fig. 3). A further important factor is the incidence of heavy autumn rainfall when the vegetation cover is thin, after summer drought. In 1971 when most of the new landslides occurred, the April rainfall in Hamilton was 123 mm, 67 mm above average.

Although gully erosion was also a serious problem in 1955, the area affected by mass slope movements was greater than that dissected by gullying. Indeed only a few headwater catchments on the 300 m plateau were free from gully rejuvenation. Main channels were incised 7 to 8 m below the 1840 flood plain level. Downstream, shifting braided channel patterns had replaced deep meandering streams, as a response to increased bed load and reduced bank stability. Today incised channels are a reminder of this

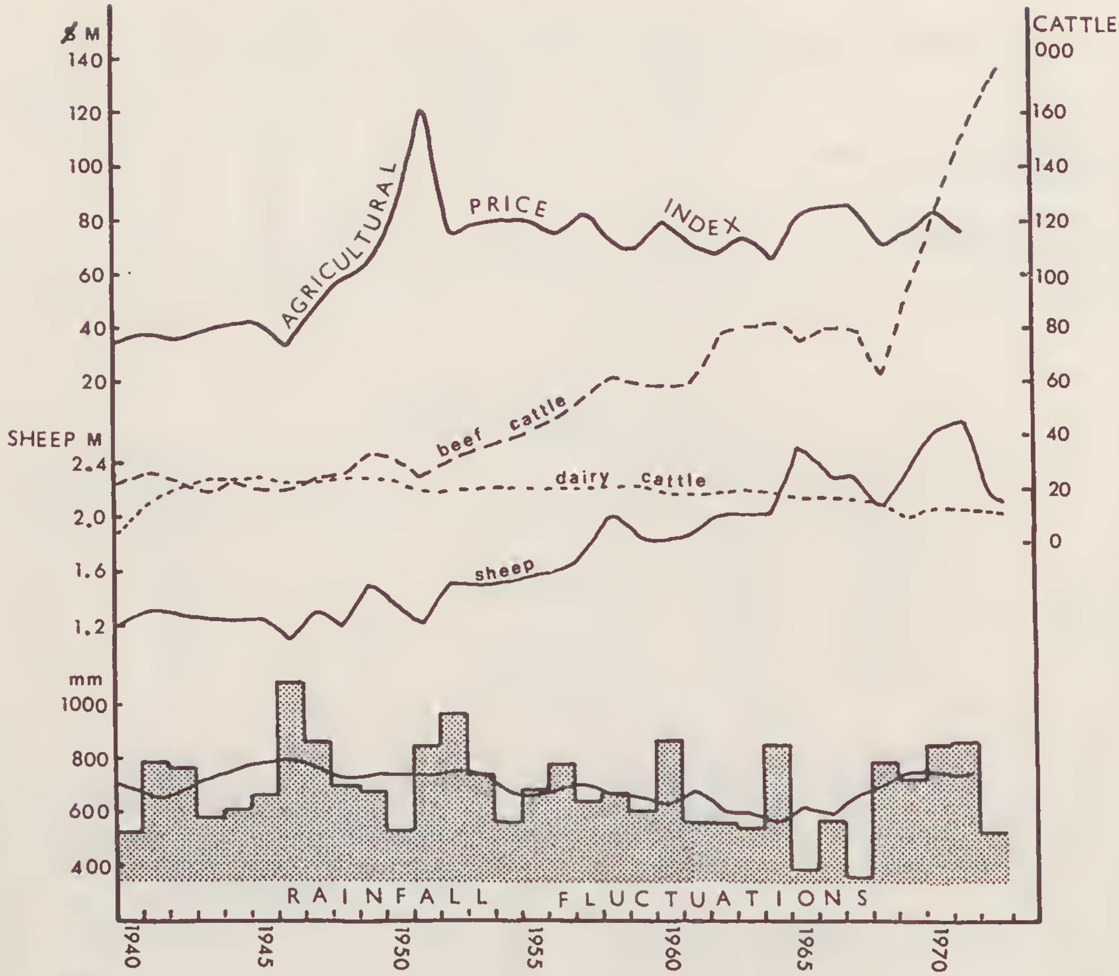

FIG. 3—Stock numbers for counties Dundas and Follett in relation to rainfall fluctuations measured at Hamilton and an agricultural price index. The agricultural price index was derived from annual values of pastoral and dairy products, modified by the annual Cost of Living Index (after Annual Statistics for Victoria). The smoothed rainfall curve is plotted from five year running means.

gully legacy but many banks, recolonized by vegetation, are slumping to new angles of rest. *Phragmites communis* is planted along banks to confine channels and *Typha* sp. is a volunteer species on many sandy gully floors. The reduction in the number of actively incising gullies is marked. Less conspicuous are the insidious effects of gully side seepage, attendant salting and slumping, of headwall undercutting and of downstream siltation (S.C.A. pers. comm.). The dominance, in 1974, of the channel network erosion problem is itself a measure of the catchment improvement that has occurred over the past 19 years.

DISCUSSION: EROSION IN TERMS OF HYDROLOGICAL BALANCE

Pre-settlement

The Dundas Tableland area is geologically vulnerable. Periods of Cenozoic incision and active slope recession have alternated with periods of stationary base level when equilibrium has been re-established. Superimposed on these geological long term changes in equilibrium have been those since 1837 on an historic scale. The latter are manifestations of changes in the hydrological balance.

TABLE 3
STILLSTAND ALTITUDES (m)

Dergholm plateau		Wannon (Coleraine)	Wannon (Murndal)	Glenelg valley	
Laterite plateau	160	200	180	180/200	
Pliocene shore	110	150 (gravel)	150	130	
? Lower Pleistocene		100	120	120	
			75/80		
		60/70	67/73	60/70	Killara delta
		±50	±50	50	flood plain

In Lower Pliocene time and possibly as late as Early Pleistocene, the laterite surface was adjusted to a shoreline at ±150 m above present sea level. Pleistocene sea level fluctuations, superimposed on a general emergence caused repercussions on landform development. Traces of stillstands can be identified as rock cut and alluvial river terraces and their knick points are still receding upstream (Table 3). The post-Pleistocene time span has been too short for the achievement of total stability. Yet the first settlers came into an area with no visible erosion, an area of timbered interfluves, grassed slopes and flood plains protected by tall tussock grass.

1837-1955

The advent of European settlement in 1837 initiated changes sufficient to upset the existing precarious hydrological balance. Water use was reduced by timber felling and ring-barking on the tablelands, by heavy stocking with concomitant decrease in perennial grass species, from 37 in 1840 to 4 or 5 by 1857, and increase in annual species (Robertson 1853) and by burning with intent or by accident. Hooved trampling, cultivation up and down slope, and destruction of the natural vegetation cover reduced infiltration. Run-off increased, sheet erosion followed, and drainage lines, vulnerable after the destruction of tussock grass, were incised, with attendant water table lowering (Marker 1959, Downes 1964). Drought at the turn of the century when stock numbers had reached a peak, followed by rabbit invasion, ensured that an eroded landscape remained the norm.

Closer settlement after 1918, tied to dairy and stock fattening, meant intensive use of small sub-economic farm holdings. By 1955 these smaller farms in the south-west of the region had attempted some pasture improvement using superphosphate and subterranean clover, but soil fertility had risen to a level inimical to indigenous perennial grass species and the land was barren by the end of each dry season. This was the situation in 1955.

1955-1974

The present improvement in the erosion position is the result of another change in the hydrological balance. Run-off has decreased and infiltration has increased proportionally, allowing the slopes to achieve equilibrium but maintaining activity along the drainage lines. Despite the reduction in interfluve tree density with the death of older trees, more land clearance, and the sale of timber during the recent recession, water use has risen on the tablelands. Higher density pastures improved by the addition of superphosphate and trace elements are utilizing more water. The re-establishment of a dense root network has improved soil structure thereby increasing water holding capacity and infiltration. On the best soils sown pastures mixtures are now used and *Phalaris tuberosa*, a heavy water user, has been planted extensively. Lucerne and *Phalaris* are also both planted on alluvial terraces. Less water runs off since more is held and used.

The elimination of rabbits by myxamotosis in the late 1950s was a further factor in the recovery of pastures and soil erosion decrease. Once the extent of rabbit damage was appreciated, rabbit eradication became a viable proposition. Not only have pastures improved and stock carrying capacity risen but erosion prone areas such as landslides and gullies are now free from warrens. Revegetation and stabilization has followed rabbit eradication. Rabbit burrows allowed water to penetrate disturbed areas, thereby promoting lubrication.

Much of the improvement is undoubtedly due to programmes initiated by the Soil Conservation Authority of Victoria since 1950, for considerable sums of money have been spent in the district. Conservation surveys pinpointed the causes of accelerated erosion, potential danger sites and urgent rehabilitation locations. Although many of the first conservation sites were selected for their severe erosion problems, the degree of stabilization and revegetation is a measure of the Authority's success. The Authority's work has both promoted and been facilitated by an increasing Australian awareness of the environment and the need for conservation. Implementation of catchment control schemes, which require the co-operation of a number of land owners, is eased in the present climate of opinion. A further factor has been a general tendency for farm amalgamation, with the elimination of small sub-economic farms, thus making the withdrawal of erosion prone areas from grazing and for conservation a working proposition. Catchment conservation programmes consisting of fencing creek banks to prevent stock trampling and to permit natural vegetation regeneration are well under way on many of the 300 m plateaus. *Typha* sp. is welcomed and some planting of *Phragmites communis* has been undertaken. Infiltration is enhanced, scour prevented and such areas incidentally become wildlife preserves.

Small earth dams are installed which serve to break stream velocity and to raise the local water table. Such sequences of dams are conspicuous in the former dairying areas near Merino. With the demand for beef cattle watering points and the realization, brought home during the recent drought, of the vulnerability of many farm water supplies, the popularity of these sequences has increased. The net result is a further improvement in the hydrological balance.

Improved pasture yields encourage subdivision into smaller paddocks. Fencing can then be aligned under Soil Conservation Authority advice, to separate slopes of different erosion hazards. Subsidized fencing of vulnerable areas has always been part of the Authority's policy and some landowners have also fenced landslide areas and planted them to kikuyu grass or trees.

A further factor in land improvement can be indicated. Following rising beef prices, lower wool prices and rising costs of wool production there has been a swing towards beef production. The number of beef cattle has risen steeply; a drop in sheep numbers is apparent since 1971, even although the momentum of the swing has not yet been fully felt. Dairy cattle numbers have been declining slowly (Fig. 3). Beef raising has affected marginal dairy farms near Merino where beef calves are now reared on the less productive section of former dairy herds. Reduction in the intensity of dairy farming has reduced trampling and the dangers of run-off concentration. Beef cattle cause less damage than either sheep or dairy cattle since they graze at lower densities, tend not to follow one another so closely and do not camp on and under erosion scars. The effects of the change in land-use to beef production on the pasture cover and infiltration rates is already conspicuous, even though the statistical significance of the change is still small when the area is considered as a whole. The improvement is most noticeable on farms that made the change some years ago.

The Future

It appears that the past 19 years have coincided with a renewed adjustment towards a state of precarious equilibrium. Slope stability has been almost achieved. Nevertheless, further changes in the form of decreasing bed load and decreased run-off but continuing seepage will necessarily continue to be felt along the drainage lines. However, the landslides that can be attributed to specific instances of mismanagement are a reminder of the precarious balance between hydrology and landform process. The 1970 Koroit landslide resulted from the misalignment of a road. Stabilization of the twin Balmoral Road landslides was achieved only after the road was altered and water ceased to drain into the slip zones. At Noss a serious landslide followed quarrying for gravel between 1920 and 1930 and stabilization is only now being achieved following the establishment of dams in the quarry floor, fencing the actual landslide, and planting to kikuyu grass.

Slumping and landslides are normal slope recession processes on incoherent parent materials overlain by clay soils. In the Dundas Tableland area, Tertiary deep weathering with fossil laterite acting as a caprock and montmorillonite-rich clay soils render the area prone to slumping. Individual landslides occur widely spaced in time and localized in position. They are triggered by factors promoting instability. Potential instability is enhanced by fluctuating climatic conditions and attendant agricultural prices (Fig. 3). However, the re-establishment of a new balance over the past 19 years despite drought conditions and an economic recession suggests that either these factors are now unimportant or, more probably, that conservation policies have gained sufficient momentum to over-ride their detrimental effects. If the latter is justified, it augurs well for the future of the region.

CONCLUSION

A marked decline in the incidence and severity of soil erosion is recorded after a lapse of 19 years despite partially unfavourable climatic and